

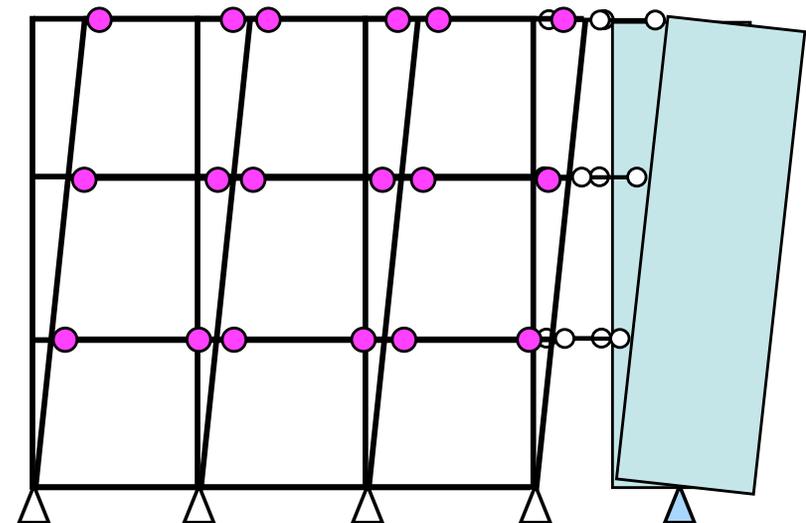
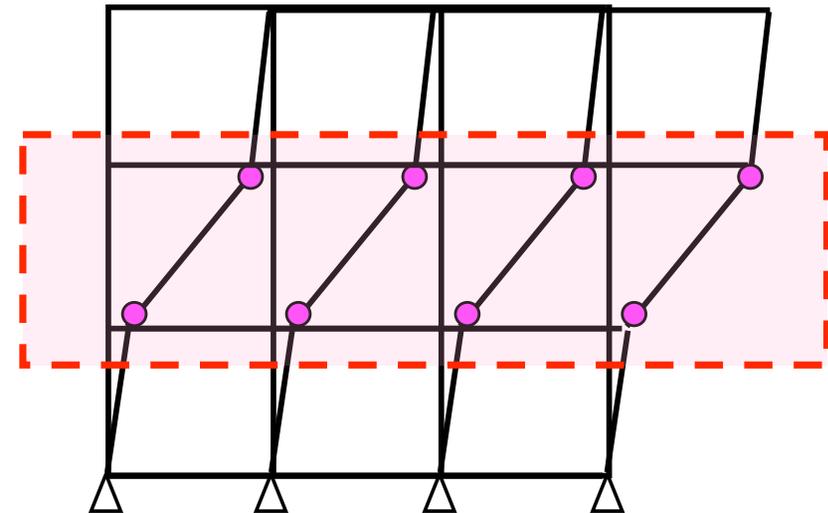
NEW DYNAMIC TESTING METHOD ON BRACED-FRAME SUBASSEMBLIES WITH STEPPING COLUMNS

Shoichi Kishiki and Akira Wada
(Tokyo Institute of Technology)

Introduction

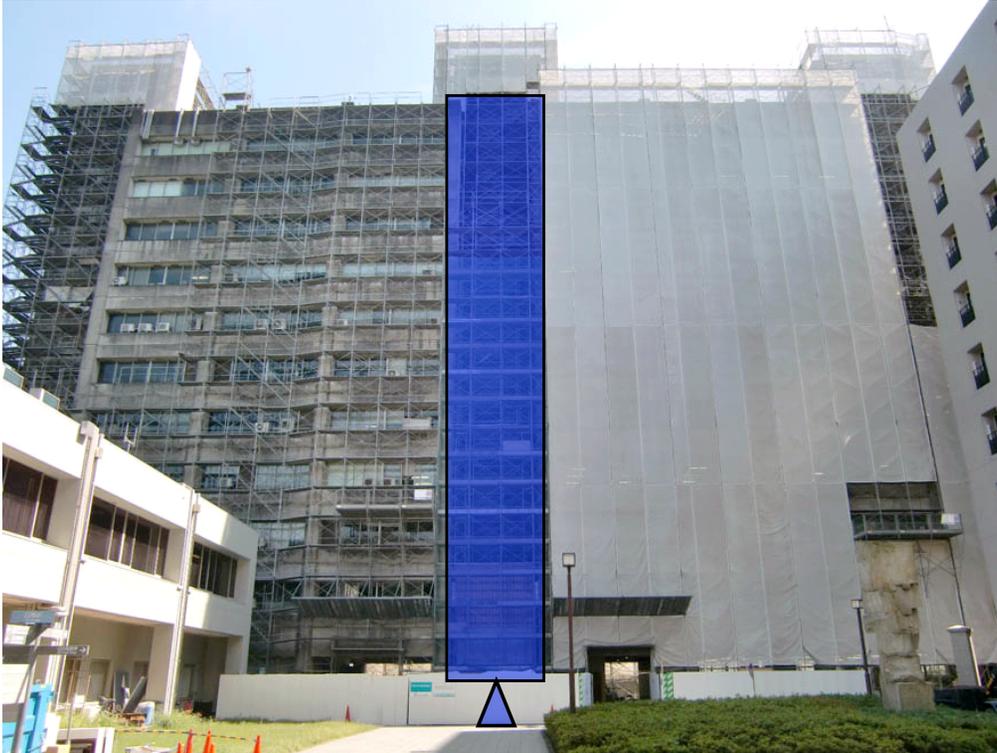
- ❑ in the Northridge and Kobe earthquakes, some buildings **lost structural functions**, although many buildings avoided collapse as to **save human life**.
- ✓ not only seismic performances but also protecting functions
- ❑ **some buildings with uplifting of foundation were no-damaged !**
- ✓ RC and steel structures with column-base or foundation allowed to uplift have been developed in the US and Japan.
- ✓ Some of these technologies can be applied to actual buildings.

retrofit project using rocking system



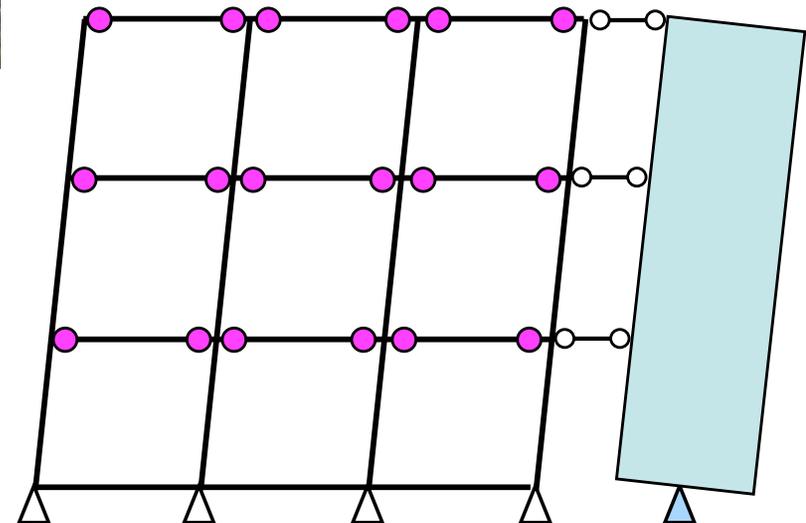
photos by Y.NAKANO (Univ. of Tokyo)

retrofit project using rocking system



retrofit project using rocking system is conducted by Prof. WADA.

G3 buildings at the Suzukake-dai campus in Tokyo Tech.
(under construction)



Rocking Controlled System



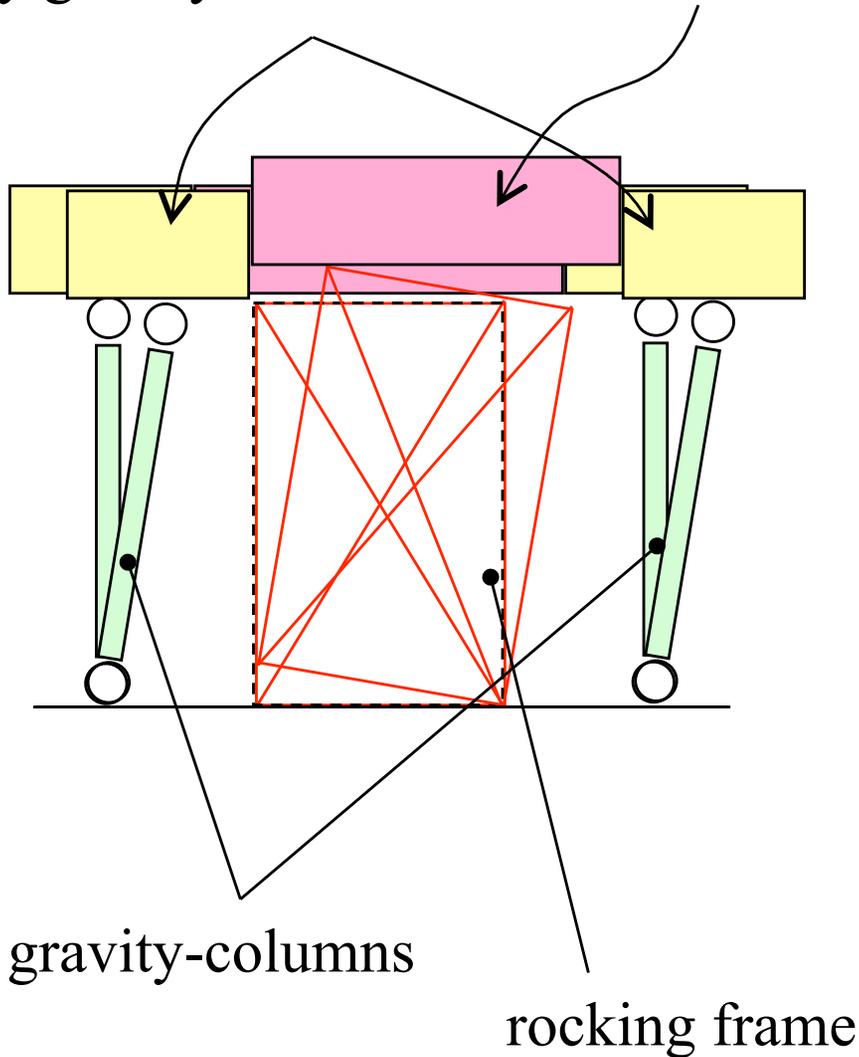
a large scale three-story frame tested at the E-Defense facility (in August 2009)

- ❑ testing a single component would be much more economical !
- ✓ The cost of such a large specimen is very high, although multipurpose inertial mass system (TEST BED) is used.

actual condition of rocking system

weight supported
by gravity-columns

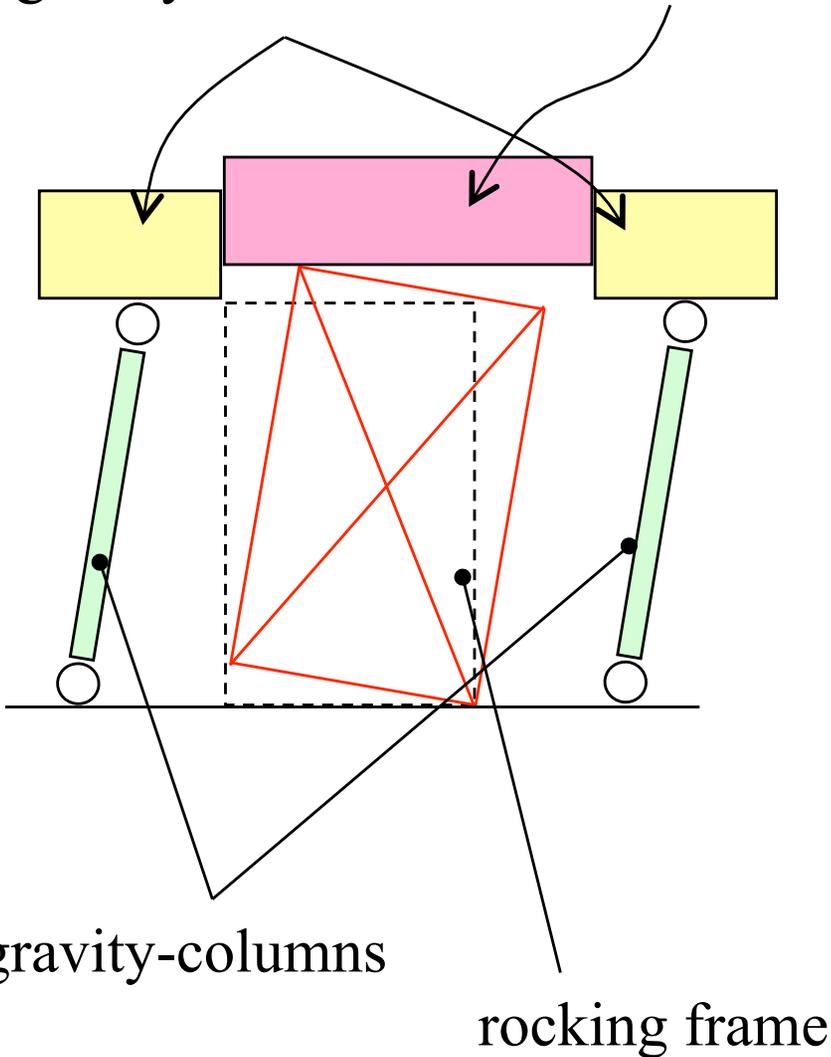
weight related to
uplift of rocking frame



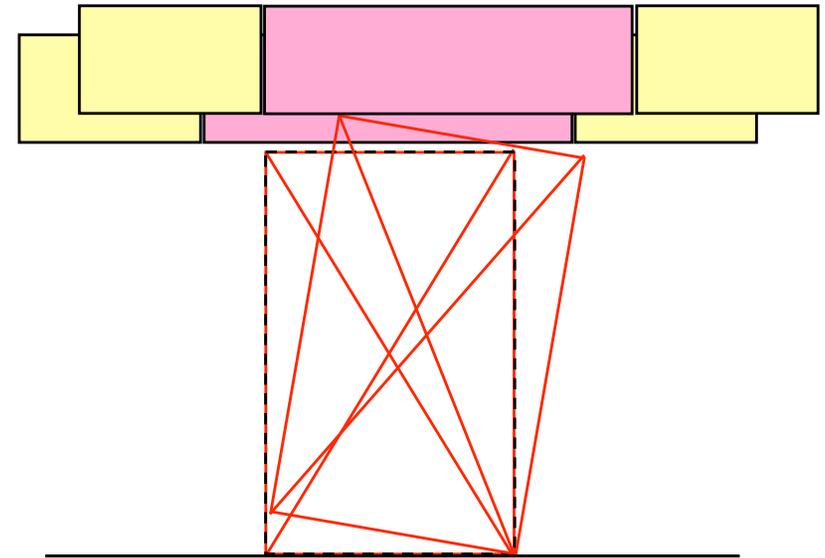
“conventional” dynamic testing method (1)

weight supported
by gravity-columns

weight related to
uplift of rocking frame



METHOD (1)

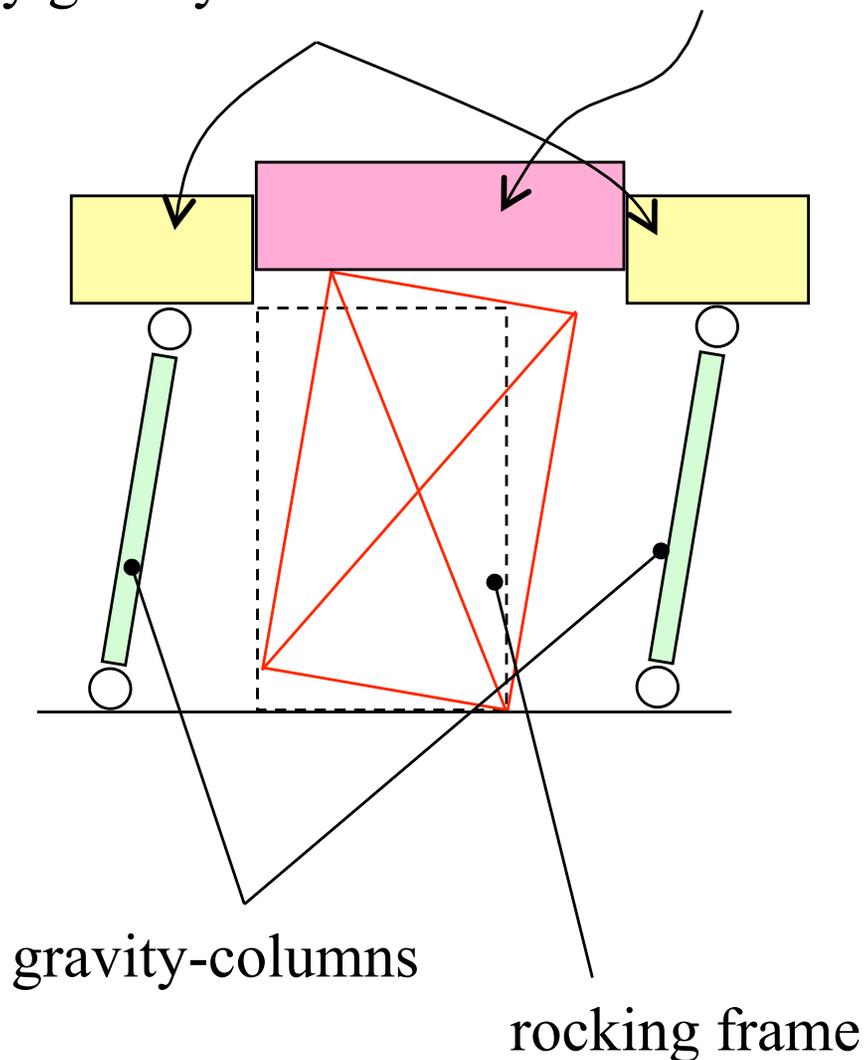


- vibration characteristic **OK**
- uplift behavior **NG**
(too heavy)

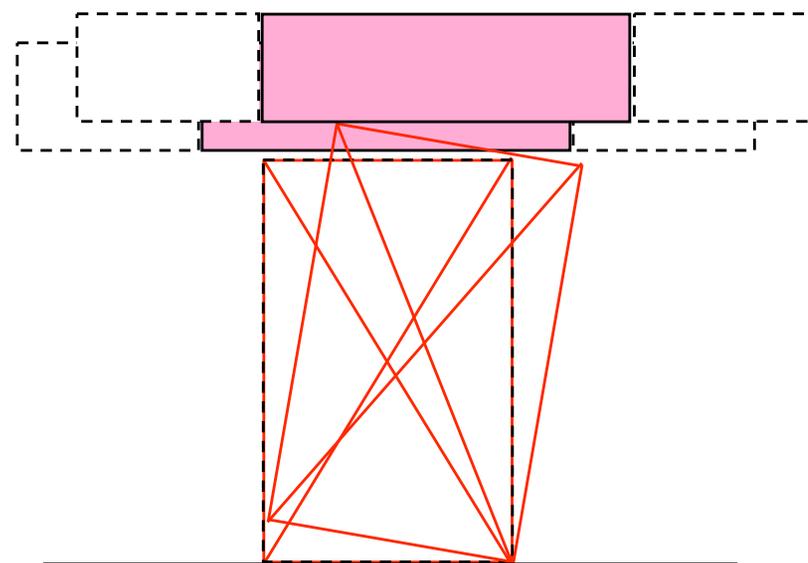
“conventional” dynamic testing method (2)

weight supported
by gravity-columns

weight related to
uplift of rocking frame



METHOD (2)

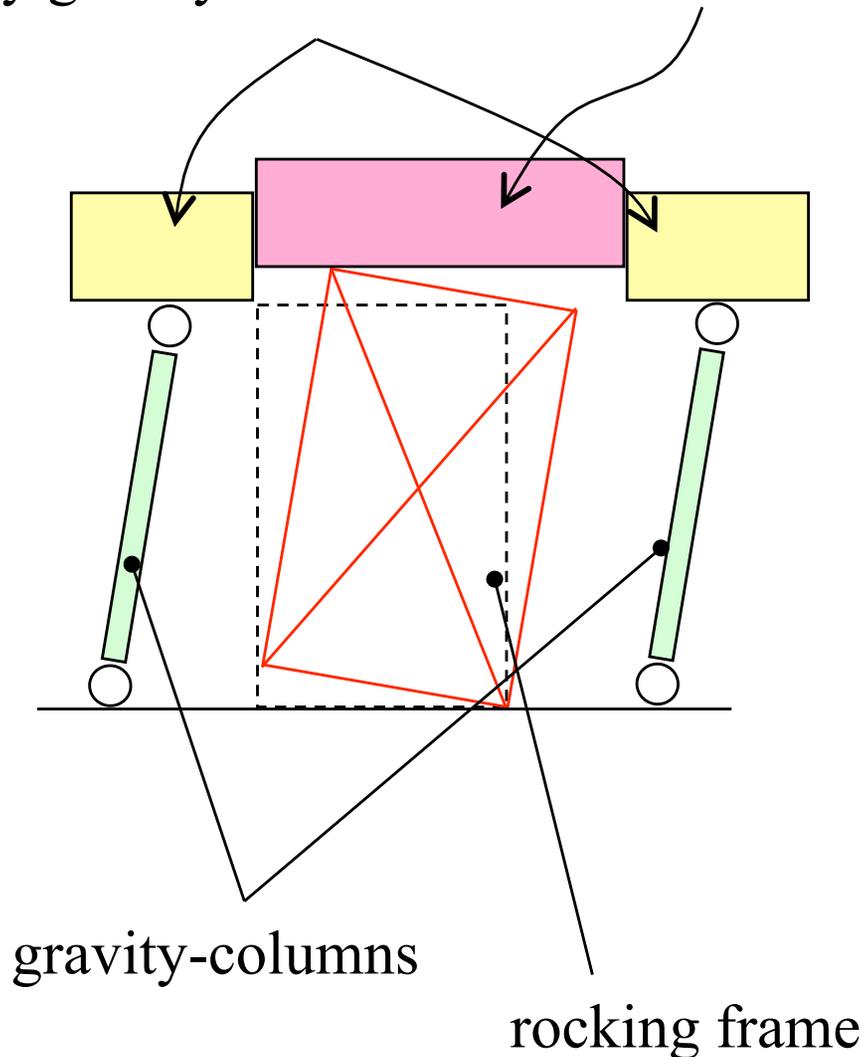


- uplift behavior **OK**
- vibration characteristic **NG**
(too light)

Needs for new dynamic testing method

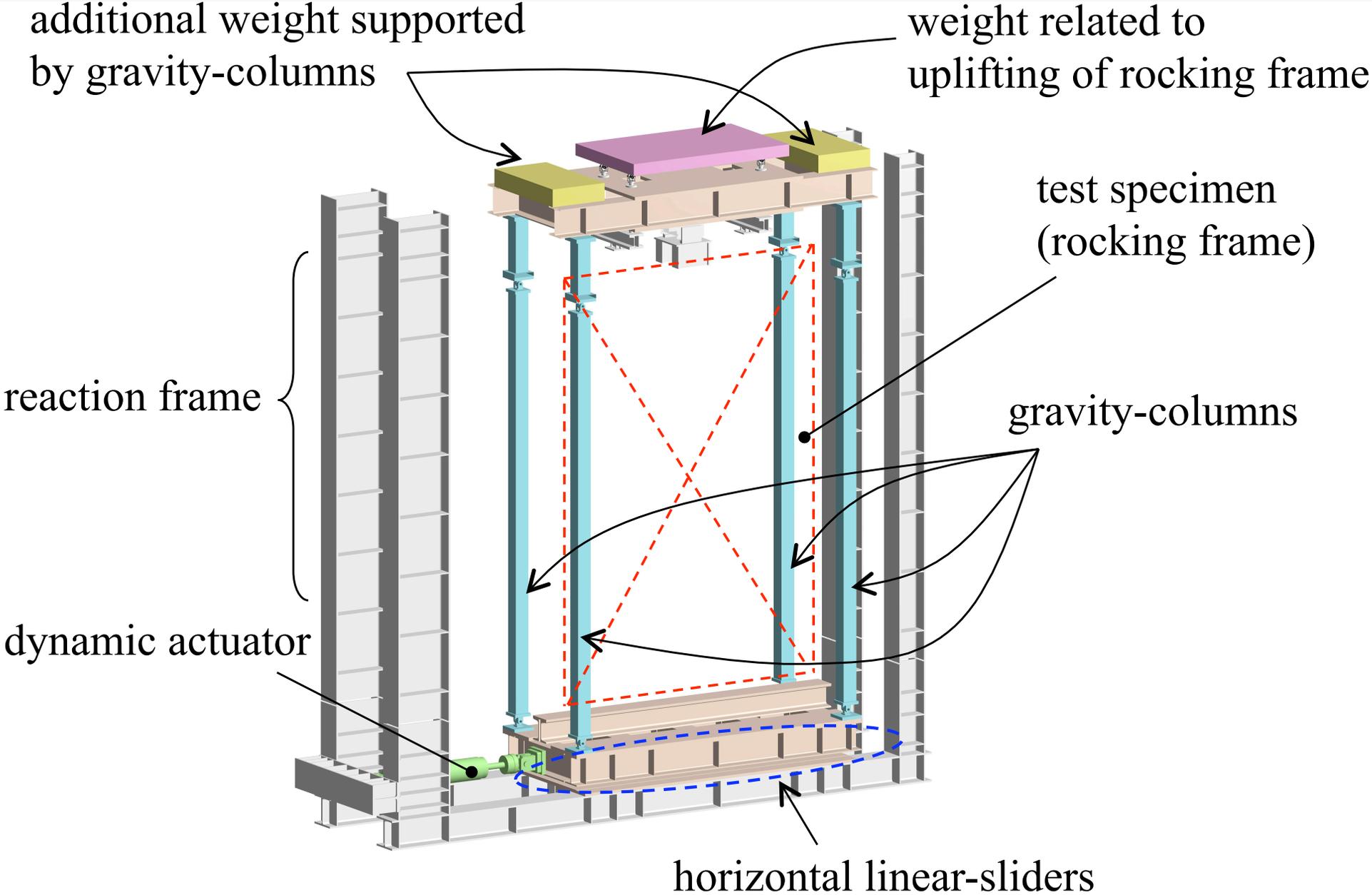
weight supported
by gravity-columns

weight related to
uplift of rocking frame

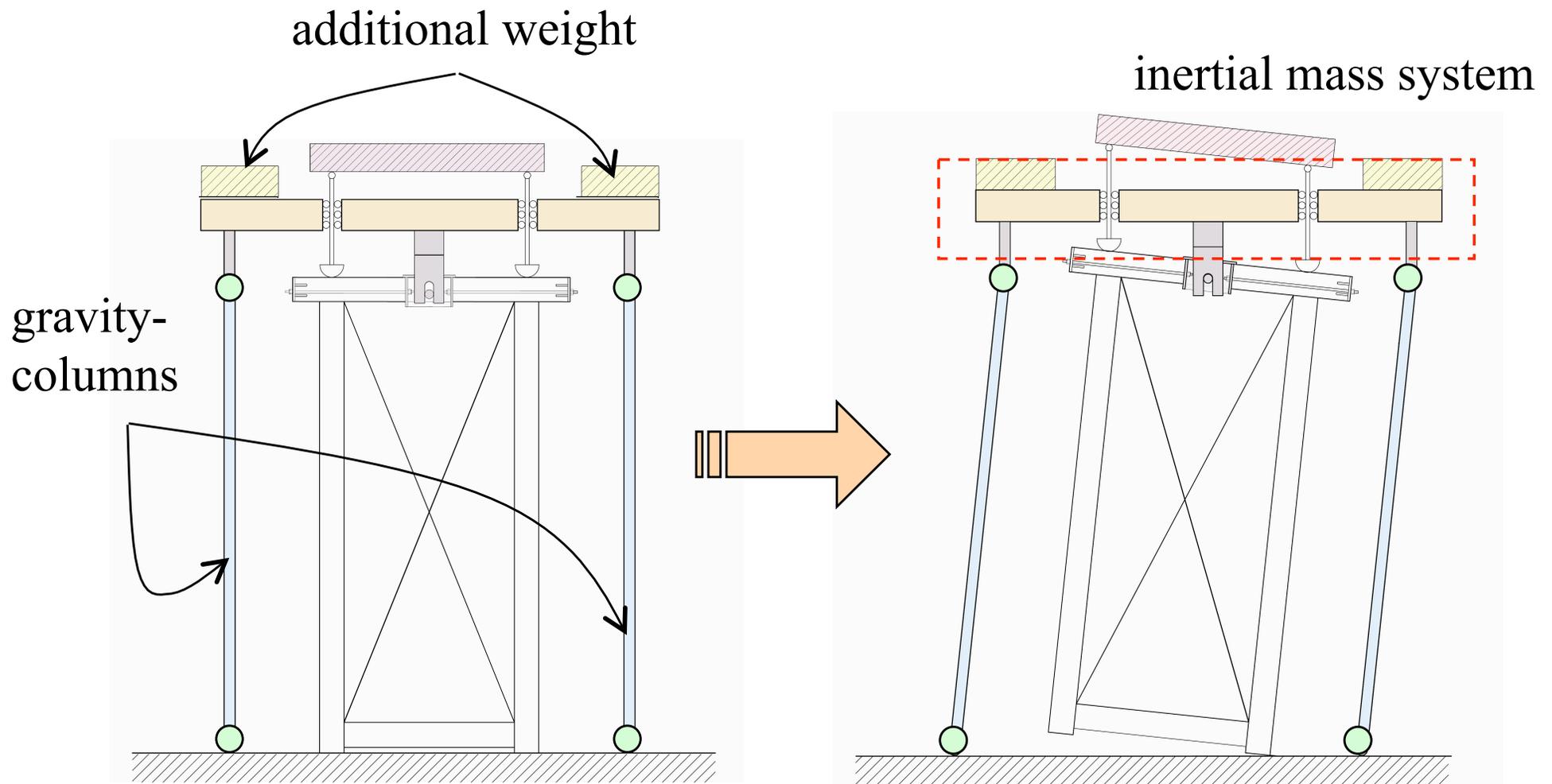


- need gravity columns and inertial mass system
- allow (pink) weight to uplift
- loading system with column-base allowed to uplift

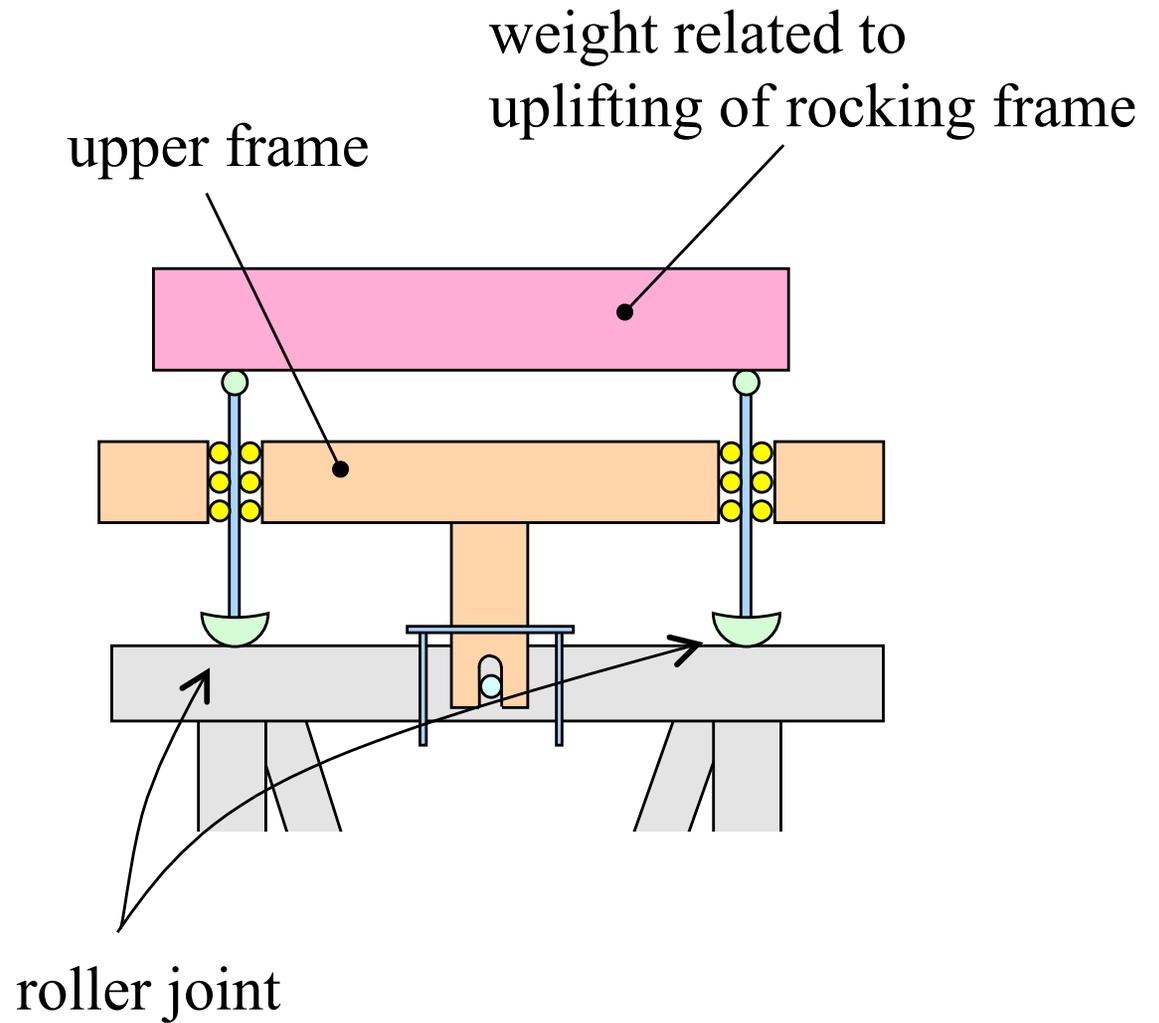
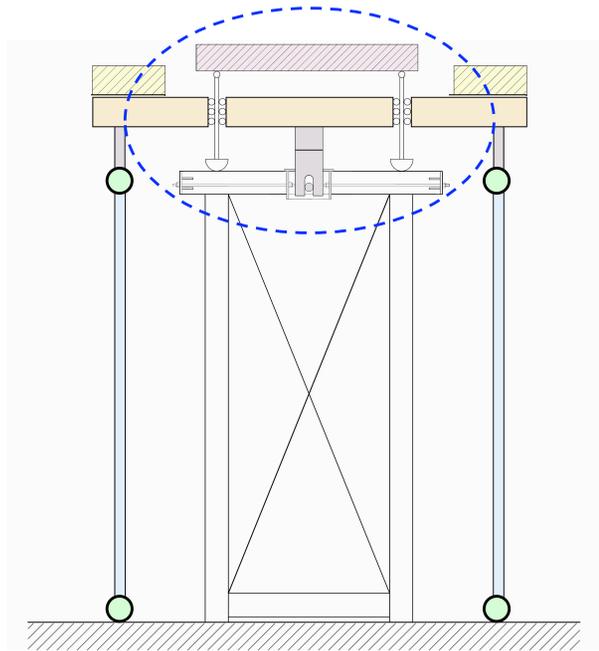
new dynamic test setup



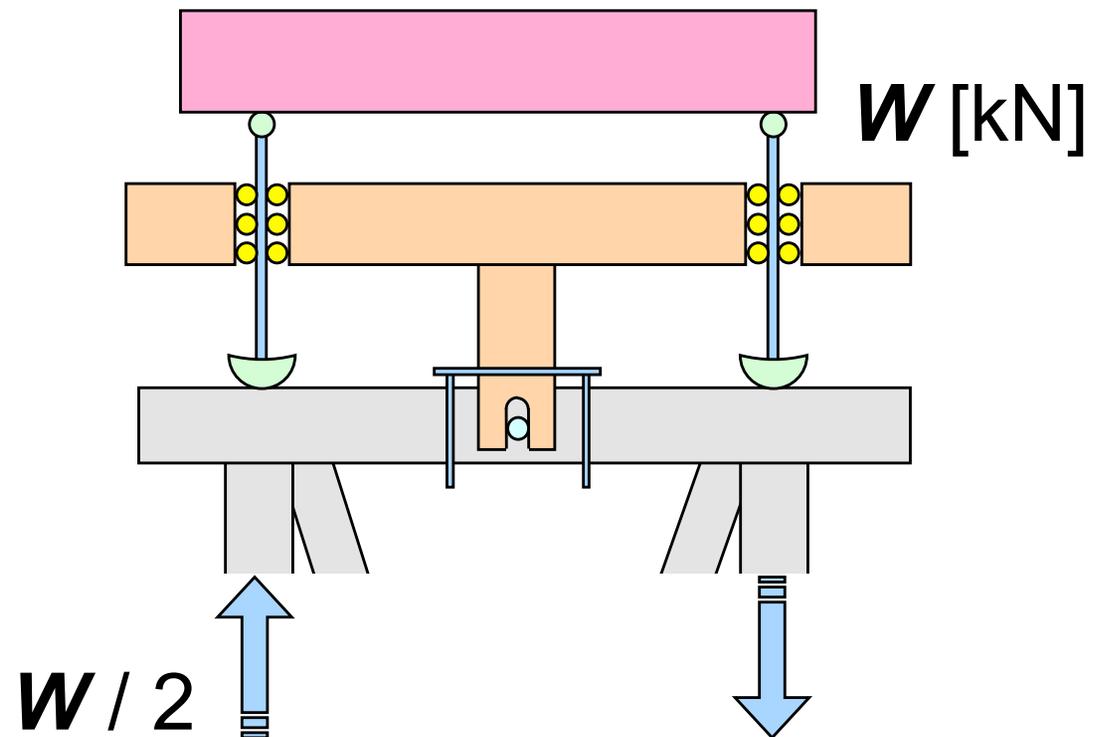
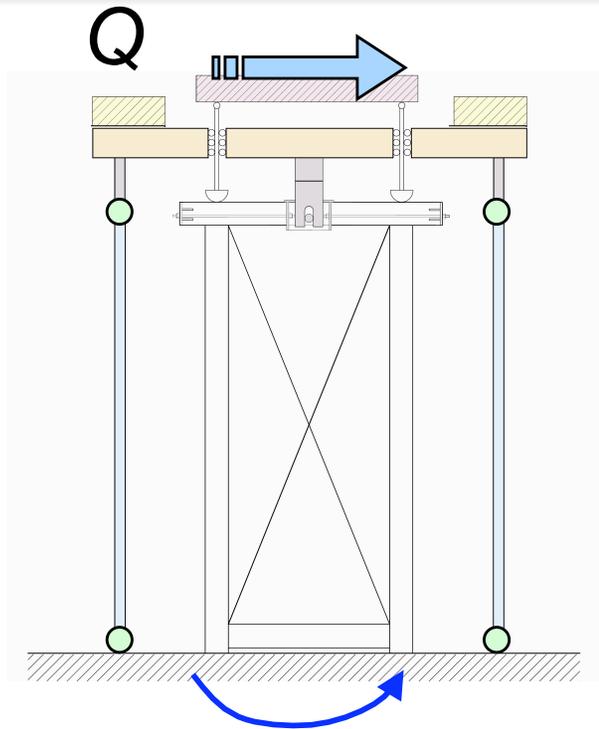
gravity-columns supporting inertial mass



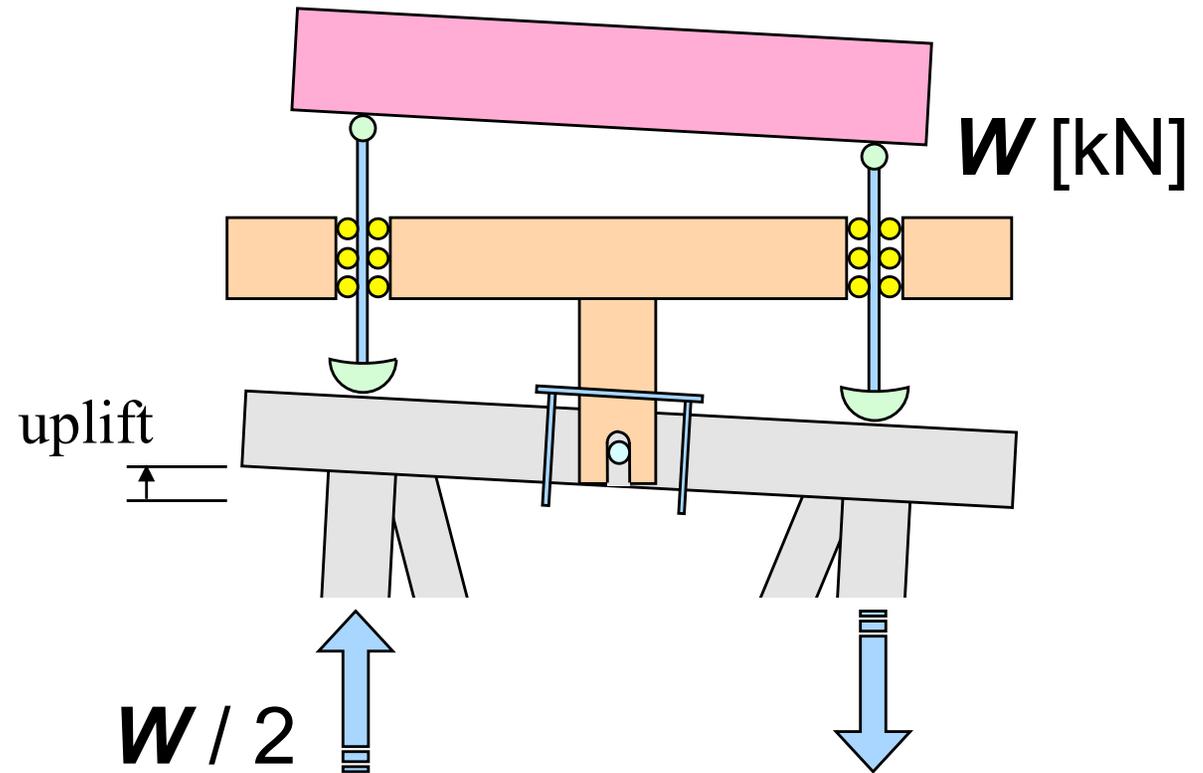
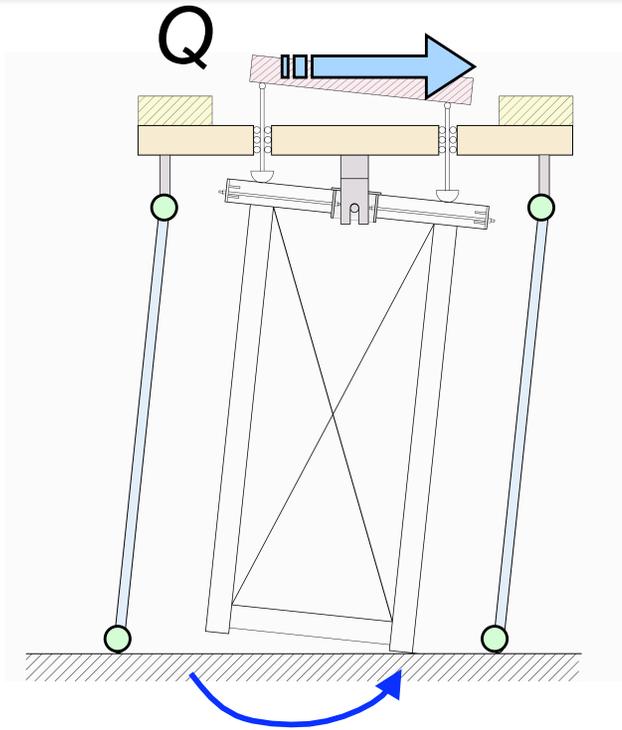
How to support main weight related to uplift



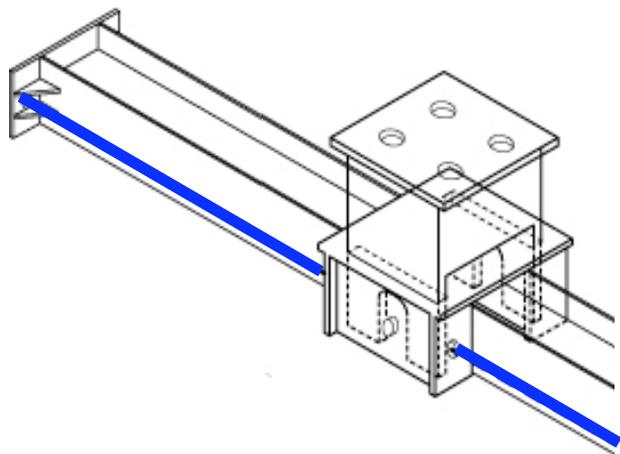
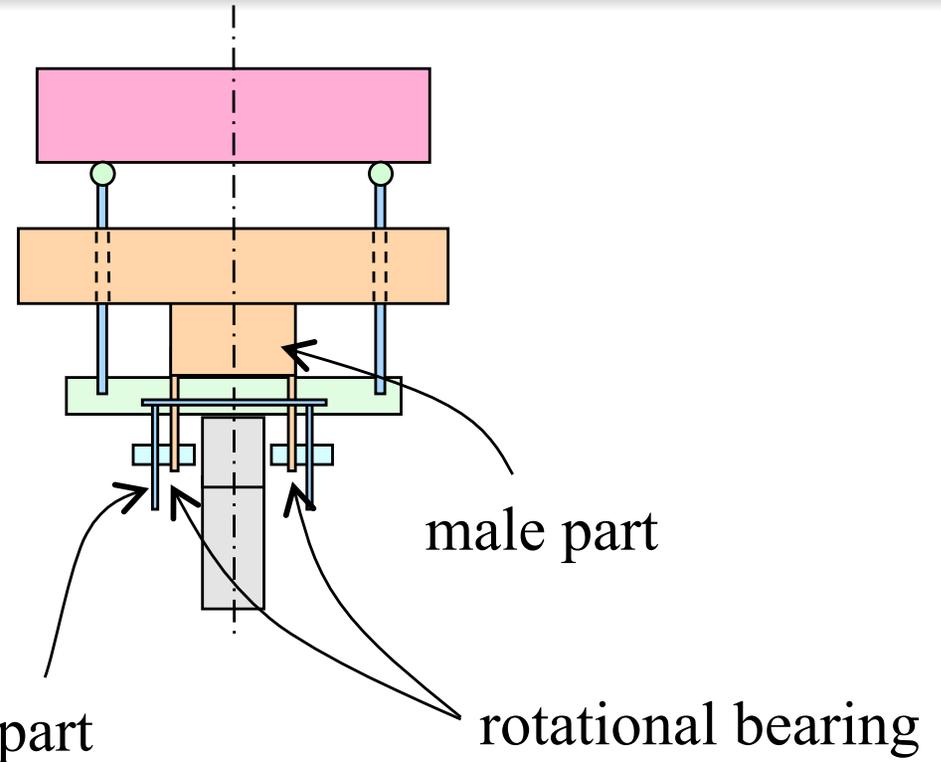
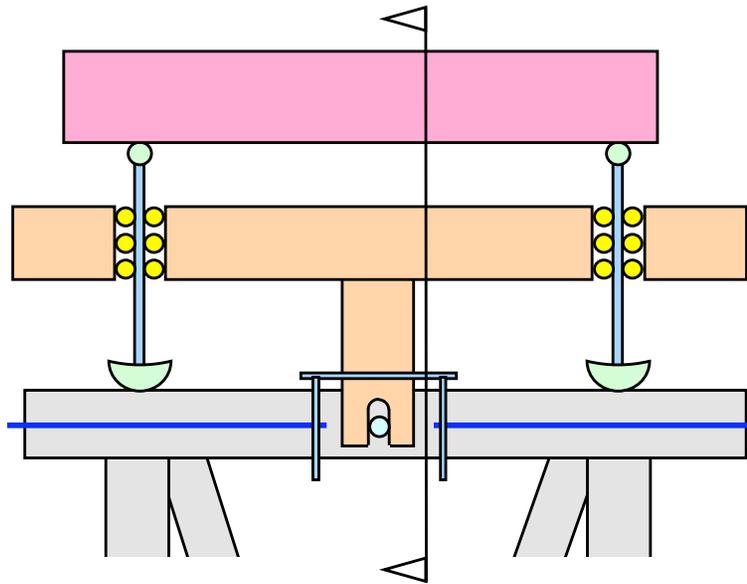
How to support main weight related to uplift



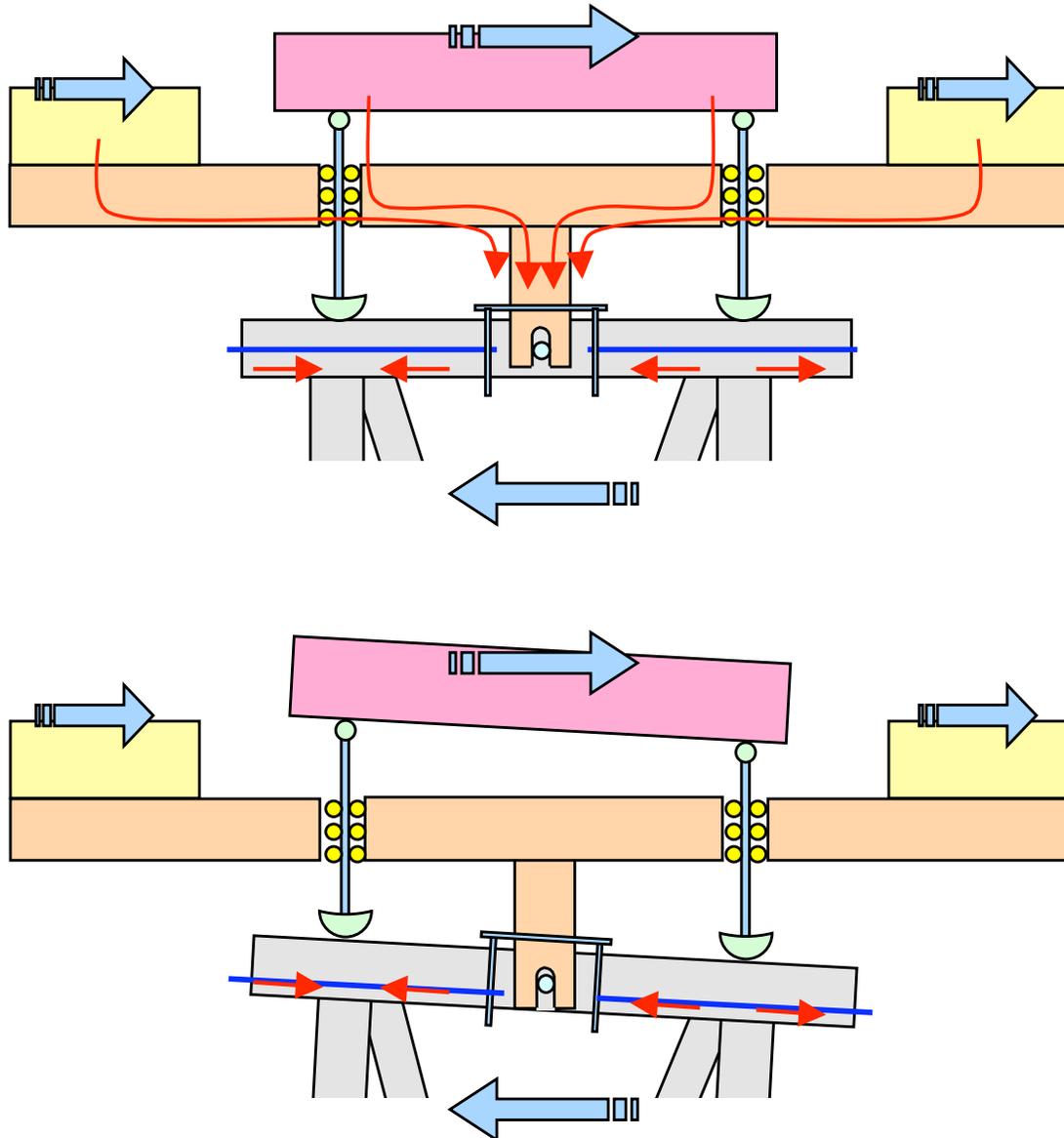
How to support main weight related to uplift



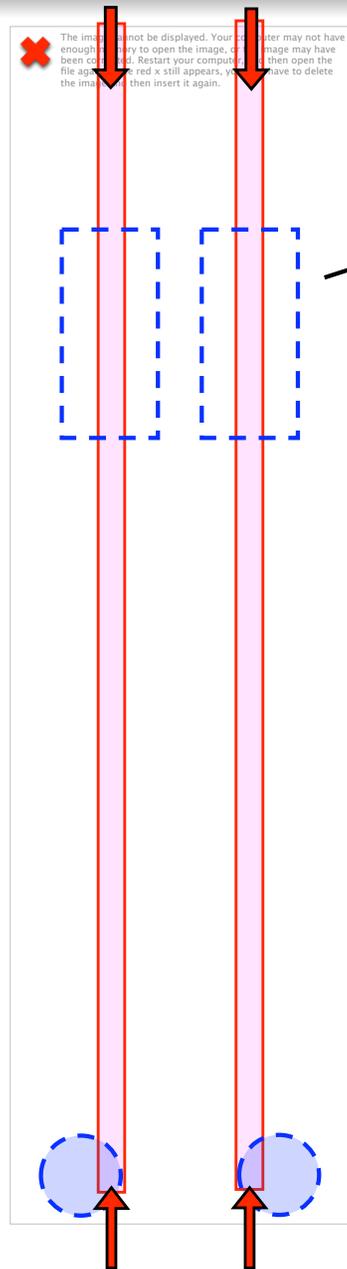
How to load with uplifting



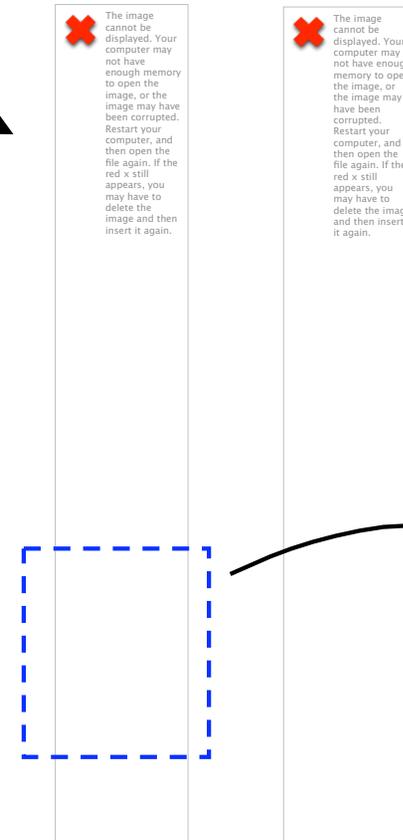
transfer-mechanism of inertial forces



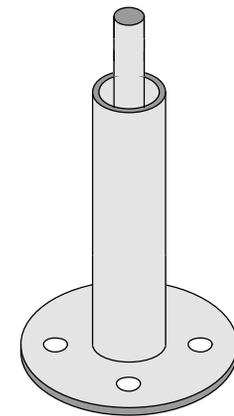
recent project using this testing system



post-tensioning devices



VEM damper



column-bases are not connected to foundation

recent project using this testing system

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Single Rocking Controlled Frame



recent project using this testing system



Dynamic Test of Single Rocking Frame

Conclusions

- In this paper, new dynamic testing method to realize uplifting of earthquake resisting frame system has been developed.
- Total weight of a building is supported by **earthquake-resisting components** and **gravity-columns**.
 - earthquake-resisting components have to **support actual weight**.
 - vibration characteristic of test specimens can be realized by **the addition of inertial mass** supported by gravity-columns.